Jet Propulsion Laboratory
California Institute of Technology

NN-EXPLORE

NASA-NSF Exoplanet Observational Research

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Why NN-EXPLORE

- **2010 Decadal Survey**
  - “...discover planets within a few times the mass of Earth as potential targets for future space based direct detection missions.”
  - **"NASA and NSF should support an aggressive program of ground-based precise radial velocity surveys of nearby stars to identify potential candidates.”**
  - "Using existing large ground-based or new dedicated mid-size ground-based telescopes equipped with a new generation of high-resolution spectrometers in the optical and near-infrared, a velocity goal of 10 to 20 centimeters per second is realistic.”

What Is NN-EXPLORE

NN-EXPLORE is a joint NASA-NSF program for exoplanet observational research.

- NASA is funding the development of the NEID radial velocity (RV) spectrograph, telescope port adapter, telescope facilities modification, guaranteed-time observations (GTO) and a guest observer (GO) program.
- NSF provides 40%-time on the WIYN 3.5-meter telescope on Kitt Peak.

ExEP(JPL) provides overall project management.

Penn State is building the NEID instrument and pipeline software and will conduct the GTO.

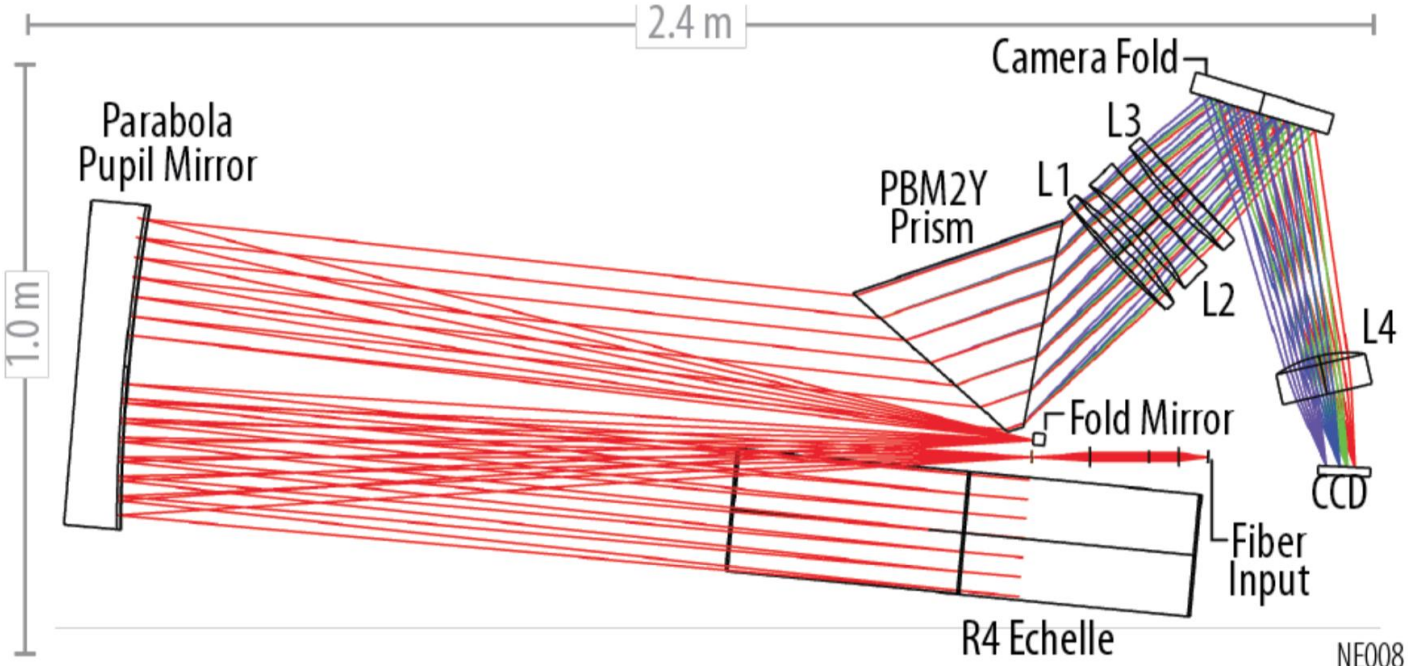
NOAO is building the port adapter and performing the facility modifications, and conducts the GO selections.

NExScI will operate the community RV data pipeline and archival database, and implements the GO awards.

NEID Spectrograph

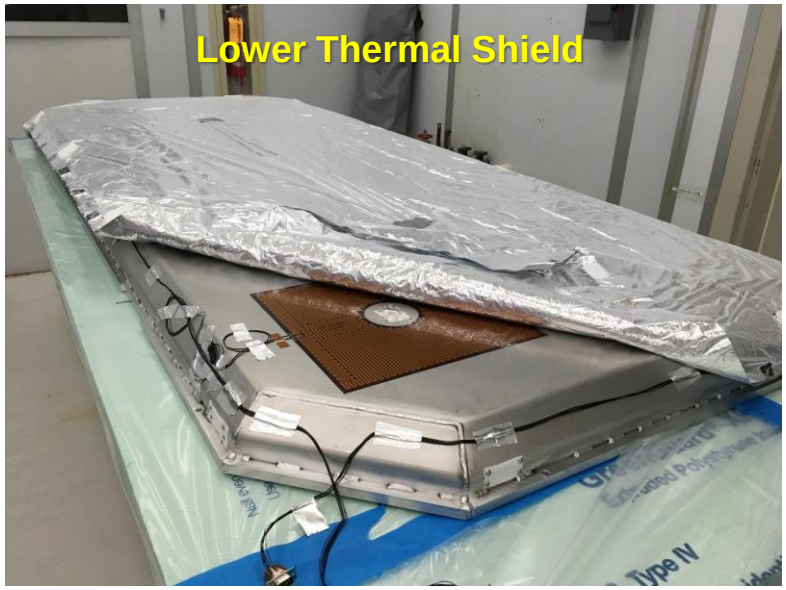
NEID - **N**N-EXPLORE **E**xoplanet **I**nvestigations with **D**oppler Spectroscopy
(O'odham for "to discover/visualize")

- Precision radial velocity of **~27 cm/s**
- **380 nm - 930 nm** bandwidth (RV coverage for F-M stars and stellar activity indicators)
- R = 100,000 spectral resolution of bright (V<12) stars
- e2v 9k x 9k CCD with 10 µm pixels
- **Environmental chamber with P < 10^{-7} torr and ΔT < ±1 mKelvin**
- **Laser Frequency Comb calibration**

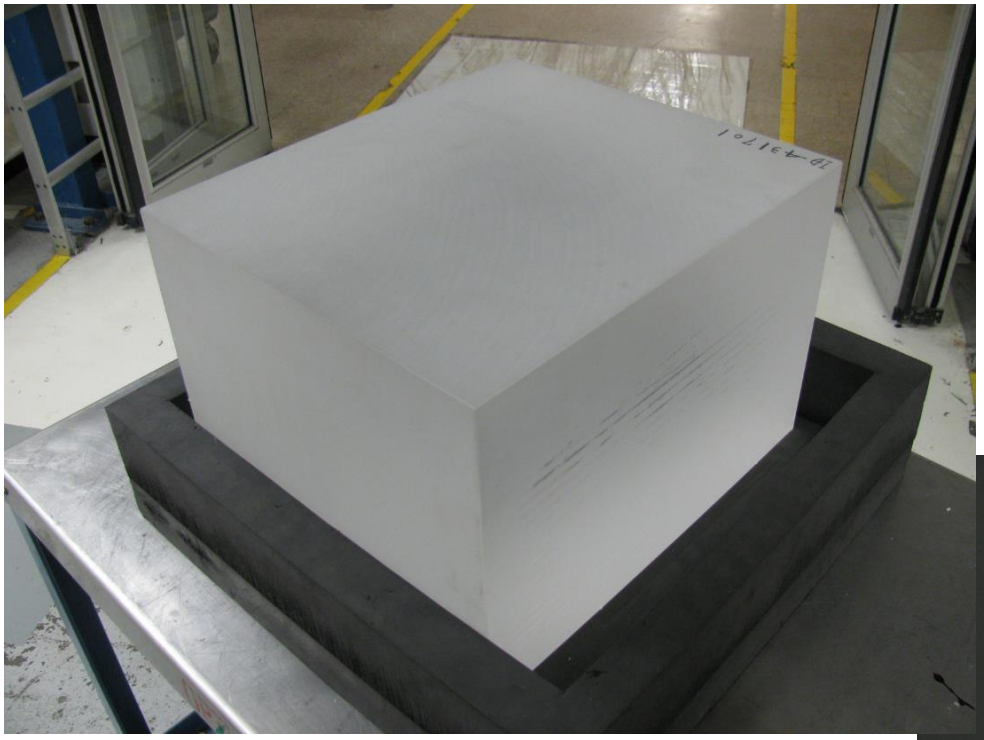


Optical Layout

NEID Chamber/ECS



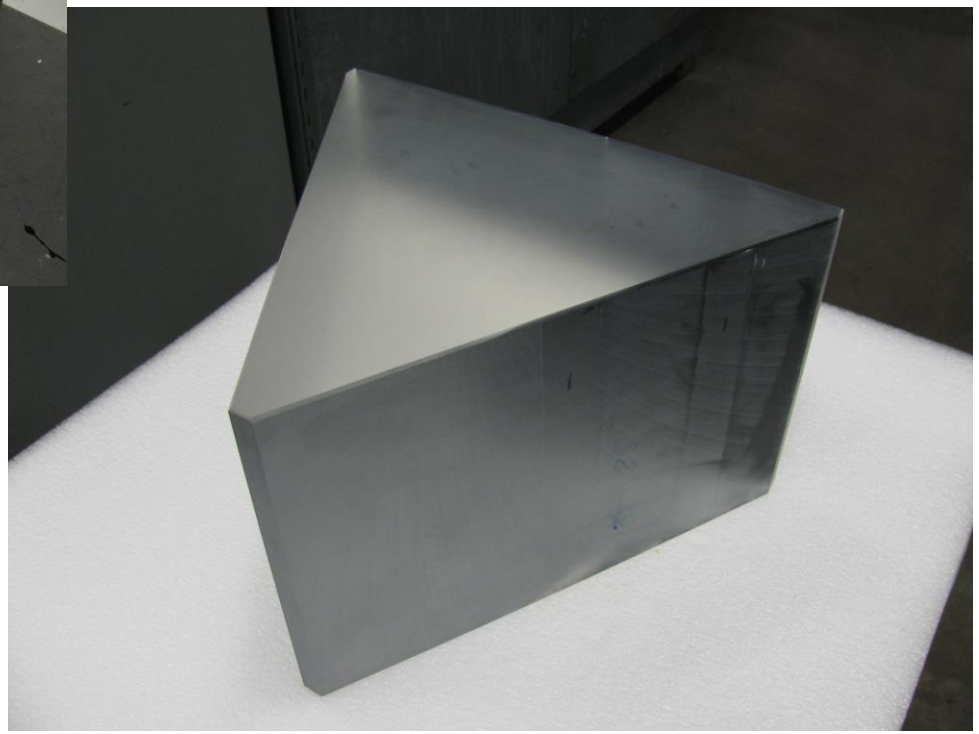
Cross-Dispersion Prism



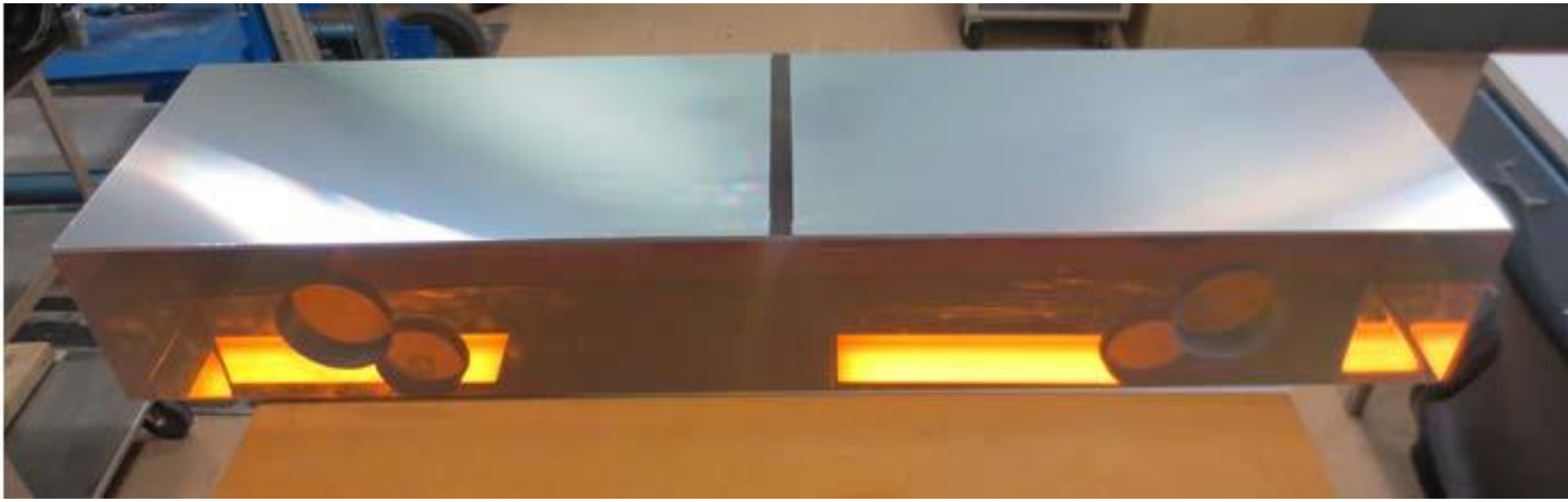
PBM2Y blank

The prism is being completely fabricated in-house at Zygo, from material acquisition to shaping, metrology and final anti-reflective coating

Shaped test blank



R4 Echelle Grating



Just completed by Newport Richardson Grating Lab.

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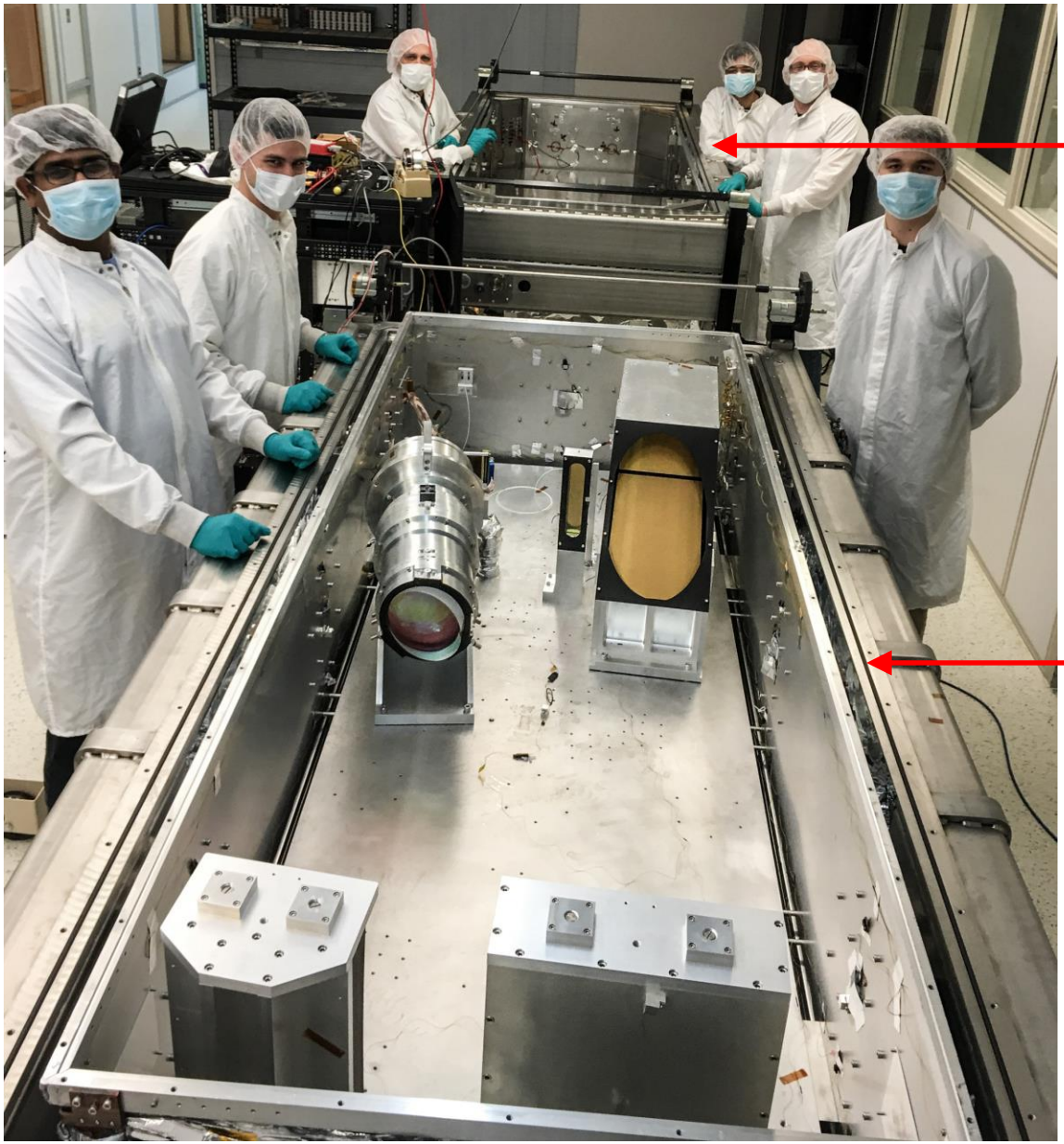
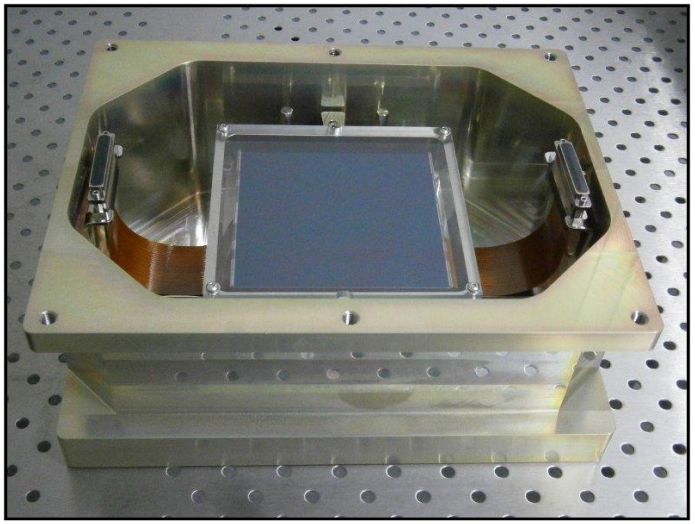
NEID and HPF



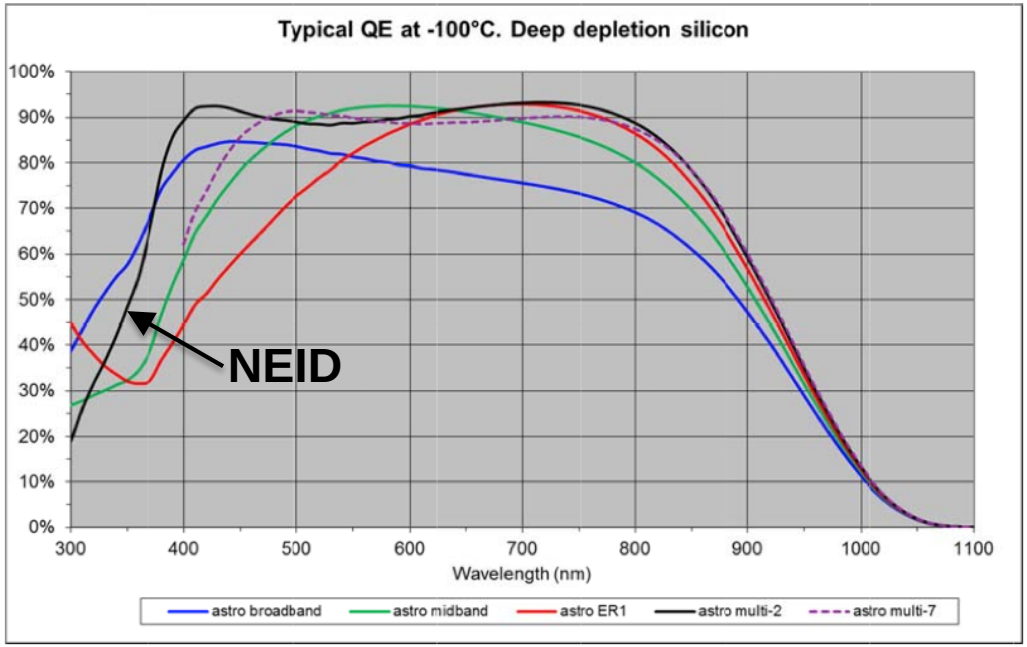
NEID
0.38 - 0.93 µm (visible)
R ~ 100,000
Δv ~ 27 cm/s
3.5-m WIYN telescope

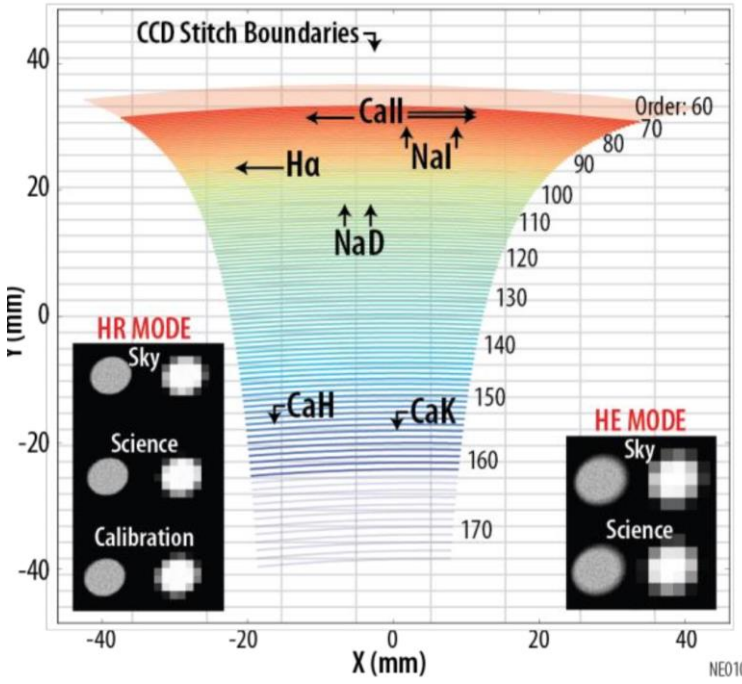
HPF (Habitable Planet Finder)
0.84 - 1.3 µm (near-IR)
R ~ 50,000
Δv ~ 1 m/s
10-m Hobby-Eberly telescope

e2v CCD



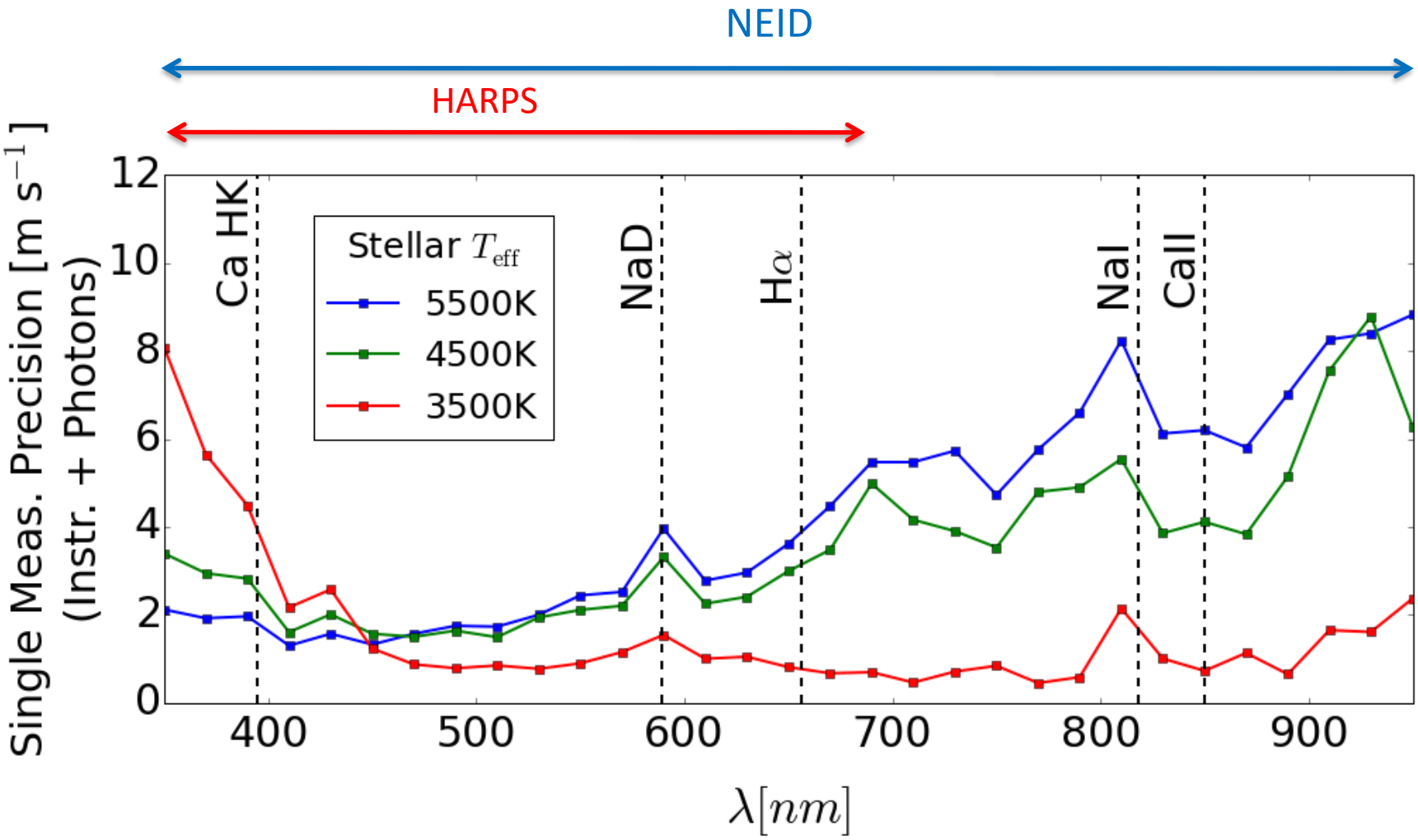
- 9k x 9k pixels with 10 µm pitch
- 40 µm thick substrate:
  - Excellent red response
  - Very low fringing at > 800 nm
- 16 readout channels
- Very fast readout possible (< 5 seconds)
- Excellent CTE: 99.9995 or better





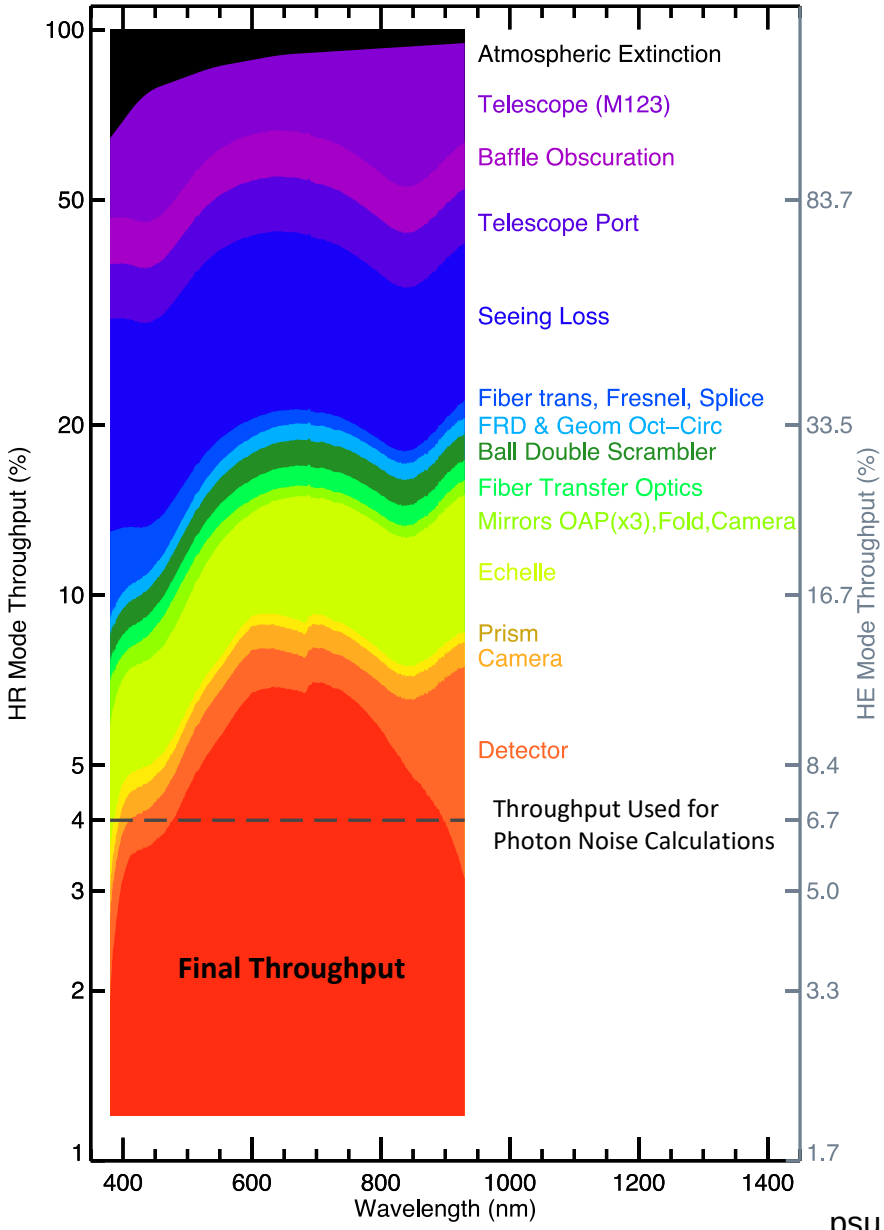
Bandpass

NEID captures the important activity indicators
and most of the Doppler information for F-K dwarfs



System Throughput

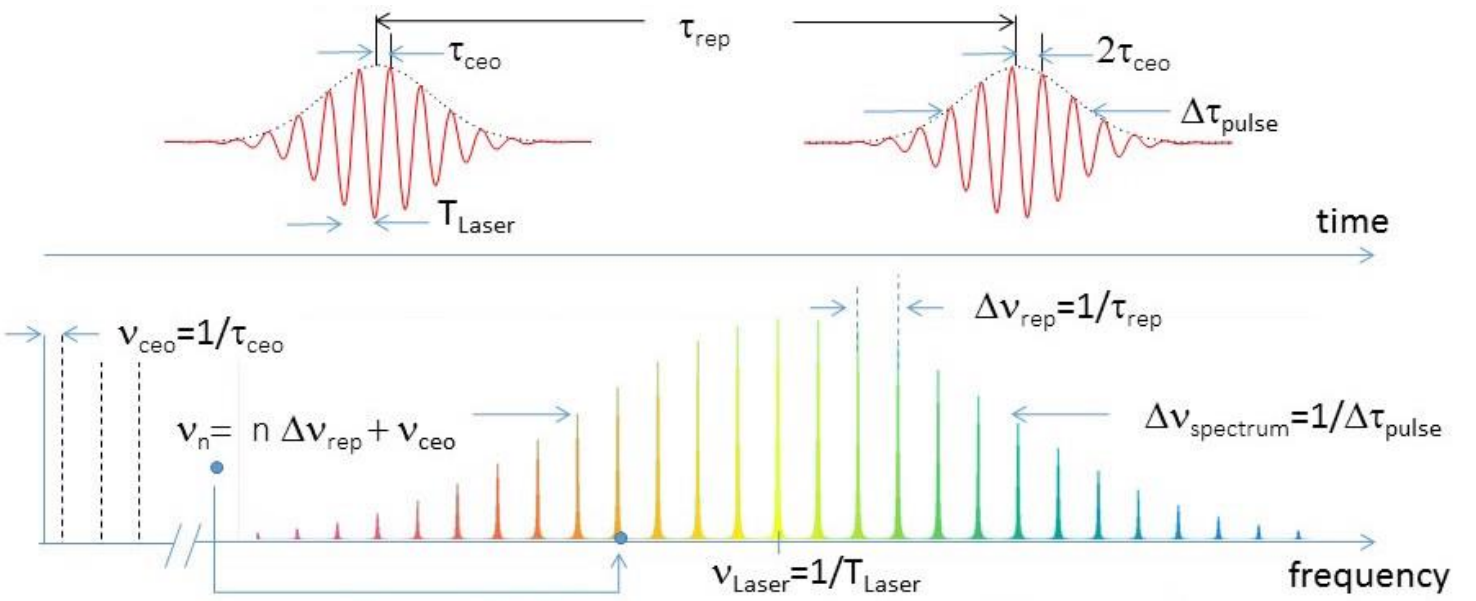
- Spectrometer throughput **38%** at 500 nm
- Mean system throughput of **5.3%** (blaze peak) over the full bandpass.
- **Matches HARPS over a wider bandpass**



Exquisite Calibration

Menlo Systems Astro Laser Frequency Comb

- 20-GHz line spacing
- 420-900 nm bandwidth requirement, 400-930 nm best effort
- Individual line centers known to < 3 cm/s
- Absolute accuracy better than 1 part in 10^{10}



RE: Institut Lumière Matière

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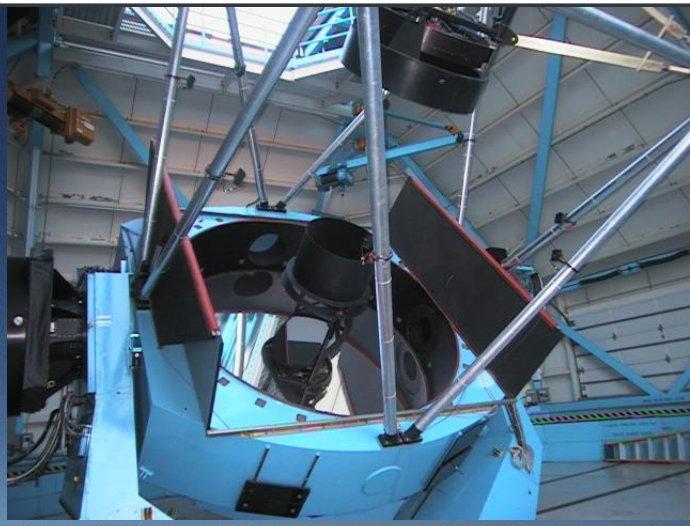
WIYN 3.5-m at Kitt Peak



noao.edu

Guest Observer (GO)

NN-EXPLORE provides a 2 semester/year Guest Observer (GO) program, administered by NOAO. There is limited funding support, sufficient to cover travel, modest research expenses, and publications costs, provided by NASA to observers under the NN-EXPLORE Program through NExScI.

http://ast.noao.edu/observing/

Stage 1 - With current WIYN instruments, targeted to general exoplanet-related research, with particular emphases on follow-up observations of Kepler/K2 targets and observations in preparation for TESS.

Semester A proposals due September 30 (awards announced mid-Dec).

Semester B proposals due March 31 (awards announced mid-June).

(66 nights awarded in 2017A, 56 nights to be awarded in 2017B)

Stage 2 - WIYN observations with NEID beginning with 2019B.

NEID instrument commissioning April 2019.

Approximately 90 nights per year of GO awarded observing.

The guaranteed time observations (GTO) is ≥30 nights per year for 5 years.

NExScI will provide the automated RV pipeline and archive database.

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2017A GO

PI		Institution	# nights	Title
Chien-Hsiu	Lee	Res. Corp. Univ. of Hawaii	3	High precision photometry to constrain the fundamental properties of very low mass stars
Verne	Smith	NOAO	6	Accurate Stellar Characterization for Kepler Extended Mission (K2) Exoplanet Host Stars
Natalie	Gosnell	Colorado College	4	Clusters with : systematics from membership and binarity
Robin	Jeffries	Keele University	4	The radii of M-dwarfs in the Praesepe cluster
Joel	Hartman	Princeton	3	Follow-up Observations of HATNet Transiting Planet Candidates with WIYN
Knicole	Colon	Bay Area Env. Res. Inst.	6	Characterizing K2 Exoplanet Candidates with High-Precision Near-IR Transit Photometry
Masashi	Omiya	Nat. Astron. Obs. of Japan	5	Spectroscopic survey of nearby late-M dwarfs for near-future Earth-like planet searches II
Kevin	Hardegree-Ullman	University of Toledo	6	Planet Occurrence around Mid-Type M Dwarfs in the Kepler Field
J Allyn	Smith	Austin Peay State Univ.	2	Exoplanet Formation In Dolidze-35
Paul	Dalba	Boston University	3	Recovering the Transit of KIC 9413313b: A Potential Exomoon Host Lost to TTV
Steve	Howell	NASA Ames	4	K2 Exoplanet Candidates: Small Planet Validation and Host Star Binarity
Thomas	Barclay	Bay Area Env. Res. Inst.	1	Exoplanetology with near-simultaneous optical and infrared transits
James	Davidson	University of Virgina	0.5	Which KOI Binaries are Gravitationally Bound?
Mark	Everett	NOAO	2.5	Speckle Imaging to Characterize late-K & M Dwarf TESS Targets near the N. Ecliptic Pole
Mark	Giampapa	AURA	0.4	Seeing SPOTS with NESSI: Starspot Photometric Observations of Transiting Systems
Nolan	Grieves	University of Florida	0.3	Investigating Binary Trends of Solar-type Stars Hosting Brown Dwarfs and Giant Planets
Joel	Hartman	Princeton	5	Follow-up Observations of HATNet Transiting Planet Candidates with WIYN
John	Livingston	University of Tokyo	2	Exoplanet Validation for K2 Campaign 10
Bo	Ma	University of Florida	1.3	Speckle imaging of Giant Star with a Long-term RV Trend
Bo	Ma	University of Florida	1.1	A Multiplicity Survey of Solar-type Stars with Brown Dwarf Companions
Nic	Scott	NASA Ames	1.5	Investigation of Exozodiacal Dust Disk Host Stars
Gerard	van Belle	Lowell Observatory	4	NESSI Survey of Potential Low-Mass Exoplanet Hosts
		Classical	42	
		Queue	23.6	
		Total	65.6	


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Partnership for Exoplanet Discovery and Characterization
NASA
NSI